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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication of Coal Mining Machinery

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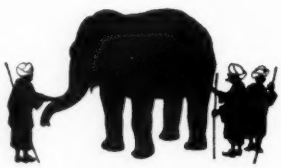

A STORY handed down from Antiquity tells how three blind men were taken to "see" an elephant.

The first one grasped the swinging trunk and asserted that an elephant was like a snake.

The second put his arms around a huge rigid leg and said "how like a tree!"

The third blind man, running his hand along the broad, rough side of the animal said both were wrong, as an elephant was indisputably like a wall.

And then they wrangled.

The trouble was that they could not combine their knowledge.

Nor did they consult some one who could see the elephant in its entirety and give them the whole picture.

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Lubrication of Coal Mining Machinery

DURING the last few years the mining of coal has developed rapidly from a pick and shovel proposition accompanied by a simple cable hoist and a few rough cars, to one involving the use of many kinds of powerful and carefully designed labor saving machines, together with many safety devices to protect the miner. By means of these machines not only is the man power required per ton of coal produced, greatly reduced, but also the famous mine mule is being slowly eliminated for the more powerful electric or air driven locomotive. In order to obtain the full value from the use of this machinery, however, extraordinary care must be taken to keep it at its highest operating efficiency, as conditions around a mine are extremely severe. No single factor is more important in this respect than correct lubrication. That this is being realized is shown by the fact that instead of the old time almost universal Black Oil—Black Strap—mining engineers now require that the most highly refined products be used and that they be applied in the most efficient manner. The small extra cost sometimes necessary to get the most suitable product and best oiling system, is quickly absorbed in the value from increased production and prolonged life of the machines, to say nothing of lowered repair bills.

In discussing the lubricating problems encountered in coal mining we will first consider the general principles involved in both anthracite and bituminous fields, and then take up the various operations, the machines employed and the grade of lubricant best adopted for each type of machine. In this we will bear in mind that it is highly desirable from a practical standpoint to keep the number of lubricants required in the plant as small as possible.

General

Veins of coal occur in all thicknesses, at all depths and at all angles of slope. The veins are sometimes sharply defined with pure products while at other places the coal is badly mixed with shale, slate or other rock. The material also differs greatly in hardness and ease of cutting. This variation has brought about different methods of mining and caused the development of many types of mining machinery. If the vein leads inward from the side of a mountain and has only a gentle slope, it can be mined by simply running a number of drifts from the surface, cutting between the drifts as much as practical. If, however, the veins are deep it is necessary to sink a number of shafts to different levels with gangways leading from the shafts in such various manners as the nature of the veins and rock may dictate. The coal is mined from headers which are run through the veins from and between gangways. Sufficiently wide pillars are left to support the

rock above the vein. The coal is carted through the headers to the main gangways where the cars are assembled and hauled to the surface either directly or by means of main hoisting shafts. The cars may then be dumped directly into railroad cars, as is the general procedure in bituminous fields, or may be hauled to the "breaker" as is the anthracite practice. In the breaker the coal is cleaned and sorted for the market.

Power House

The heart of the plant is the power house. Here electrical, pneumatic and mechanical power is produced by means of large reciprocating engines or turbines. Both electrical and pneumatic power is used extensively about the mine, and it is a matter of supreme importance that the supply of both be continuous, as even a short interruption of power may bring disastrous results. It is therefore requisite that the lubricants used in power apparatus be of the best quality and exactly suited to the purpose.

The lubrication of steam turbines was considered in the February and April, 1921 issues of LUBRICATION, but there are a few points that may be emphasized. If a circulating oil system is used, either gravity or pressure force feed, the oil must be of such a highly refined character that it will separate easily from water and sludge. Care should be taken that the lubrication system is so designed that there is sufficient capacity in the system to allow a reasonable time for the settling out of the water and sludge that is unavoidably present. In large systems a special filtering unit is advisable in order to keep the oil in the best condition.

If turbines are direct-connected to electric generators, a medium-light bodied oil of 180″ to 200″ Saybolt viscosity at 100° F. is recommended. If, however, there are reduction gears and both the gears and bearings are lubricated from the same system, it is necessary to use a heavier bodied oil of 300″ or even 500″ viscosity in order to have the gears operate satisfactorily. This viscosity is a little high for bearings but the difficulty is very satisfactorily met by using an oil that lowers its viscosity rapidly with temperature rise.

By using an oil with this physical characteristic and running the bearings at a little higher temperature than usual, the problem is very satisfactorily solved.

With small turbines direct-connected to pumps and other apparatus where ring oiled bearings are used and the oil supply is local to the bearing, the temperature is usually much higher than where a general system is used, and therefore an oil of higher viscosity must be used. A heavy oil of 500″ Saybolt viscosity at 100° F. is recommended.

The electric generators, motors and rotary convertors, if on a separate system from the turbines, require a medium bodied oil, either of 200″ or 300″ Saybolt viscosity, depending on the unit bearing pressures encountered.

The external bearings of reciprocating steam engines require a medium bodied oil of about 300″ viscosity. If water is encountered, as in the case of enclosed crankcase engines where there is a tendency for the oil to emulsify, particular care must be taken to obtain an oil that is highly refined and filtered so as to meet these conditions, and which will separate easily from water.

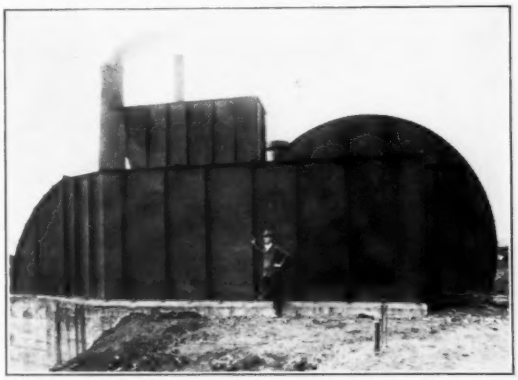
The type of oil to use on steam cylinders depends on whether the engine is condensing or non-condensing, the use to which the steam is to be put and the condition of the steam coming from the boiler. This was considered in detail in the June 1921 issue of LUBRICATION. As a rule the engines are at a distance from the boiler house and the steam arrives at the cylinder in a wet condition. The boiler water also is apt to be poor, which may cause priming. This condition necessitates the use of a compounded oil in order to prevent the oil film from being rapidly washed off from the cylinder walls by the water and condensed steam. If the condensed steam is to be used in feed water heaters or returned to the boilers, it must be free from oil. A straight mineral oil without compound, of course, separates more easily from water than a compounded oil and hence one would naturally suppose that it would be the best to use where the condensed steam is utilized for other purposes. But it is believed that the conditions in the cylinder are of primary importance and a compounded oil should be used even if it is necessary to install oil separators in order to re-use the condensed steam. By using an oil with 5% to 8% compound of suit-

able character and properly made, the cylinder conditions can be satisfactorily met and yet a separation of the oil from the condensed steam can be made without difficulty. The viscosity of the cylinder oil for low pressure steam should be about 130″ Saybolt at 210° F. while for high pressure steam it should be about 160″.

One of the most important pieces of machinery in the power house is the Air Compressor. In the coal industry air at pressures ranging from 100 to 1500 pounds is used, the pressure depending on the conditions and types of mining apparatus employed. Where high pressures are used the compressors are of the three-stage type with water jacketed cylinders and intercoolers. The lubricant usually found most satisfactory is a highly refined and filtered light bodied oil of about 200″ Saybolt viscosity at 100° F. This is found to atomize freely, lubricate all the parts, discharge with the air and not remain in a liquid state in the cylinders and pipe lines. The air around a mine is very dusty and when drawn into the compressor the dust will mix with the surplus oil, forming a sludge which under the effects of the high temperature may cause disagreeable deposits. Only under extraordinary conditions should a cylinder stock be used, and above all it should be the aim to use as small a quantity of oil as is possible and yet get satisfactory lubrication. This subject was treated in detail in the June 1920 issue of LUBRICATION. The external lubrication of air compressors is similar to that of reciprocating engines.

Ventilation

Let us now proceed to the mine. One of the most important factors in coal mining is the ventilating system. There are always deadly as well as inflammable gases concealed in the various coal pockets, and even the coal dust itself may be as explosive as the gases if it comes in contact with a spark or flame. These gases therefore must be continually removed in order to make a mine safe and workable. This is accomplished by means of gigantic fans 20 to 30 feet in diameter, which suck out the foul air, blow in fresh, or both, by means of air shafts and ducts. When the suction system is used the fresh air enters through the working or hoisting shafts. The various gangways, headers, galleries, etc., are so arranged that there is always a current of air in them. As soon as the coal is exhausted from a header it is closed up by "brattice work" so that the air is forced through another header that is being worked. The words "slope" and "plane" are used to designate the direction of the air current for the air always flows "down a slope" and "up a plane". Special ducts and chutes are cut through the rock so as to furnish a sufficient supply of air to a point which would not



Courtesy of The Jeffrey Manufacturing Company

Fig. 1

Multi-bladed Mine Fan. Compare the size of the fan with the man standing in front

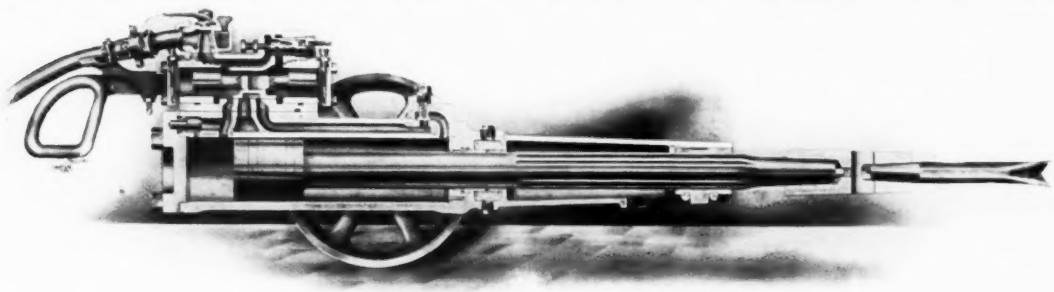
otherwise be properly ventilated. In addition to air currents, water sprays are often used to settle the dust where it is excessive. The large fans used to bring about the air circulation are driven either by small reciprocating engines or by electric motors. As the engines are usually at a considerable distance from the boiler house the steam reaches the cylinders in a wet condition, and a compounded oil is necessary. As, however, the service is continuous the cylinders remain warm, and an oil with a moderate amount of compound, 5% to 8%, will operate satisfactorily. As these engines are apt to be more or less unattended their external lubrication and that of the motors is best accomplished by grease cups, using a medium grade of grease.

Mining Machines

Generally in the anthracite field and in some bituminous fields, coal is still mined by simply drilling deep holes in the veins and bringing out the coal by blasting. In this case the work is done by hand, electric or pneumatic drills,

or augurs. These are usually lubricated by a medium grease, though in the case of air drills a low pour test oil is often found more satisfactory as the temperature around the valve may become quite low due to expanding air.

In most bituminous fields, however, a large number of labor saving machines have been introduced which not only give increased production but also produce a better grade of coal. One of the principal machines used to replace labor is the mining machine. There are a number of types of this machine, each being particularly efficient under certain conditions, as hardness of coal, character of impurities, condition of top and bottom walls, width and thickness of vein, pitch of vein, etc.



Courtesy of Ingersoll Rand Company

Fig. 2

Air-driven Puncher Machine Mounted on Carriage

Among the prominent types of mining machines used are: 1. Pick or Puncher; 2. Breast; 3. Shortwall; 4. Overcutting; 5. Longwall; 6. Archwall. Some of these may be further subdivided into Disk, Chain and Bar machines, depending on the type of cutter.

Courtesy of The Jeffrey Manufacturing Company

No. 3

Breast Machine. This machine drives a chain cutter directly into the underside of the vein, moving forward on the carriage as shown. After a cut is made the carriage must be moved sidewise.

(1) The Pick or Puncher machine operates similarly to a gigantic air drill mounted on some kind of a flexible and easily movable stand. It may be either electrically driven by means of a cam and spring or by a solenoid, or it may be driven by air, similarly to the air drill. Some designs combine both electric and air principles, the compressed air being produced by an integral electric motor. Puncher machines may be mounted on a movable truck, but this is not practical if the pitch of the vein is over 15°. The principal advantage of this type of machine is its low cost and its flexibility. These machines are generally best lubricated by a soft grease.

(2) The Breast machine operates on the principle of driving a chain, containing a lot of barbs or picks, into the underside of a vein. In the breast machine the chain operates around the periphery of a triangle, the base being forced into the coal while the apex remains at the machine. This cuts a kerf several inches thick on the underside of the vein the width of the triangle base and 6 to 8 feet deep. After the triangle has reached the depth desired it is withdrawn, the machine moved to one side and another cut made. This is repeated across the face.

(3) The Shortwall or continuous machine operates in a somewhat similar manner to the Breast except instead of a triangular cutter, a long and narrow one is used, which is capable of cutting sidewise as well as on the end. By this machine a cut can be run across the face of the vein continuously and time and labor saved.

(4) The above machines cut on the under surface of the vein. The Overcutting machine

Courtesy of Sullivan Machinery Company

Fig. 4

Shortwall Coal Cutter showing chain cutters and conveying truck

is so arranged that the cutter can be adjusted as to height. This is advantageous for removing seams of clay or dirt embedded in the coal and cutting a high kerf where it is advisable to shoot upwards.

(5) The Longwall machine is similar to the above except the apparatus is mounted on a truck which runs along the face of a long wall.

Some of these types of machines are also made with disk or bar cutters as well as chain cutters. The disk cutters operate in a similar manner to a circular saw, while the bar cutter works like an elongated milling cutter. Each of these has its advantages and disadvantages, depending on the conditions. These types of cutters are not used to any great extent in the U. S. but are used in European countries.

The lubrication of these machines varies considerably depending on the design. Some machines can be lubricated by a soft grease or an oil of about 300″ viscosity. In other cases where gears and bearings of these machines are oiled through the same channel this is best accomplished with a heavy oil applied immedi-

Courtesy of The Jeffrey Manufacturing Company

Fig. 5

Shortwall Coal Mining Machine in Operation

Courtesy of The Jeffrey Manufacturing Company

Fig. 6

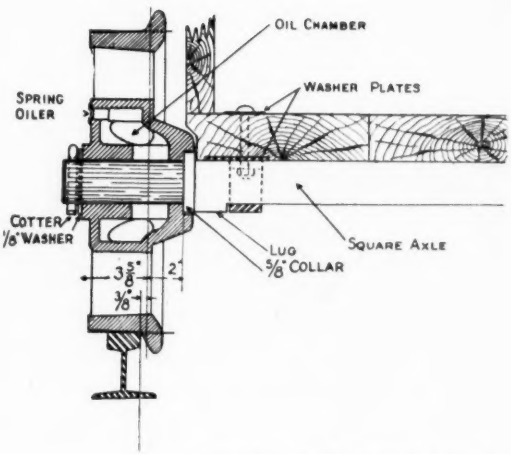
Longwall Coal Mining Machinery in Operation

ately after cutting each place, while the machines are hot. The armature ball bearings on many machines can only be lubricated with an engine oil of about 200″ viscosity as in order to keep coal and grit out the oil holes are made so small that only a light oil will reach the bearings. Where a dust tight cap and large oil holes are provided a light grease is generally preferable. The cutter chains generally use black oil. Care should be taken to clean not only the chains but the machines quite often, as they become dirty very quickly and their life will be greatly prolongated and their efficiency increased by close attention. Some operators soak the chains in oil after cutting each room. The wheels of mining machine trucks and trailers are similar to those found on mine cars and their lubrication will be considered under that head. The mining machines when loaded for travelling, drive the trucks through a worm and gear which in turn drives the wheels by means of chains. The worm and gears are best lubricated with a medium grease and the chains with the heavy oil used on the gears.

Mine Cars

After blasting down the coal it is loaded onto mine cars for transportation out of the mine. There are a number of loading machines on the market as well as combination cutters and loaders, but there is nothing in their lubrication which is not considered in other pieces of apparatus.

Mine cars consume more lubricants than all the rest of the equipment about a mine. Originally cars were equipped with plain bearing axles which were lubricated by a cheap grease or by a black oil applied daily to each wheel. On account of the labor expense involved in this method of lubrication and the large quantity of oil used, mine car manufacturers have developed a number of types of wheels which can be lubricated with much less expense, both as to labor and material, and at the same time have their efficiency increased. These wheels may be classified according to construction as (1) Plain Bearing; (2) Cavity Type Wheel; (3) Solid Roller Bearing; (4) Flexible Roller Bearings. These types may be installed on fixed or floating axles.



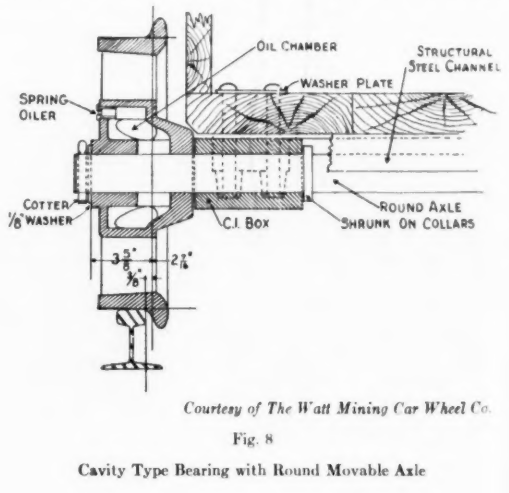
Courtesy of The Watt Mining Car Wheel Co.

Fig. 7

Cavity Type Bearing with Fixed Axle

On plain wheel bearings either with or without yarn packing an oil of 300″ Saybolt viscosity at 100° F. gives the best lubrication if the bearings are in first class condition, otherwise a good grade of black oil will give as much satisfaction as anything. Where wool yarn is used care should be taken that it is of good quality with high capillarity. It should not be packed too tight, and should be loosened occasionally or it will glaze over and become inoperative. It also should not be over-saturated as this tends to destroy its elasticity.

Cavity type wheels are equipped with an oil reservoir around the hub and may be open ended or capped. The oil in the reservoir is fed to the bearings through port holes staggered in the hub of the wheel and is fed to the



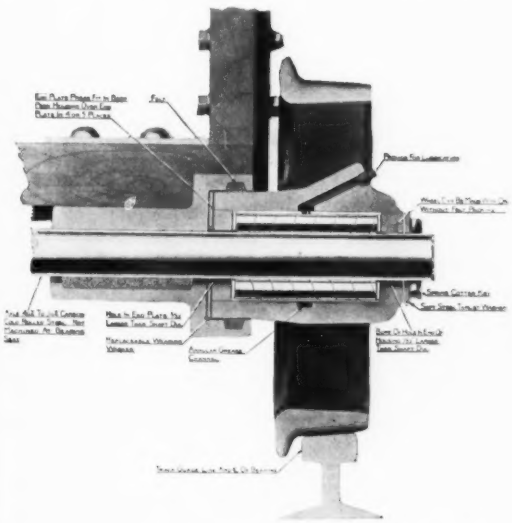
Courtesy of The Watt Mining Car Wheel Co.

Fig. 8

Cavity Type Bearing with Round Movable Axle

bearing only when the car is running slowly. When the car is in rapid motion the centrifugal force keeps the oil suspended around the outside of the reservoir. This type of bearing requires a lubricant of a semi-fluid nature and with a low pour test. Many operators owing to the difference in cost per gallon, use black oil for this purpose. However, when labor and length of service is taken into consideration, a grease especially prepared for the purpose will be found to pay. On the other hand if the rolling stock is in poor condition a high grade grease cannot cure the trouble and is wasted.

With solid roller bearings a soft grease is found to be satisfactory as it is continually kept in motion and its body furnishes a better cushion between the rollers and the axle than a more liquid product. The grease on account of its



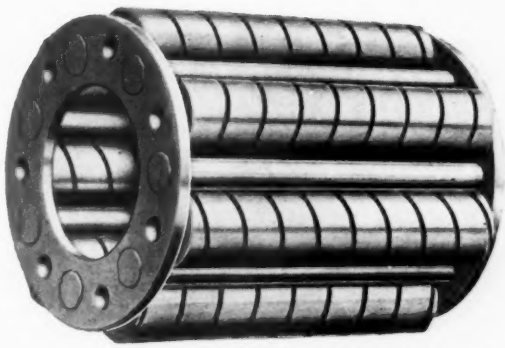
Courtesy of Hyatt Roller Bearing Company

Fig. 9

Flexible Roller Bearing Installed in Mine Car

body also has the effect of keeping out dust and dirt and is less affected by moisture.

The flexible type of roller, as the Hyatt, requires a semi-liquid grease, as due to its construction the hollow space in the roller acts as a reservoir and the grease must be fluid enough to flow out and not remain dead in the roller. Both types of roller bearings can be lubricated with a squirt gun. Roller bearings are especially adapted to cases where the cars move rapidly.



Courtesy of Hyatt Roller Bearing Company

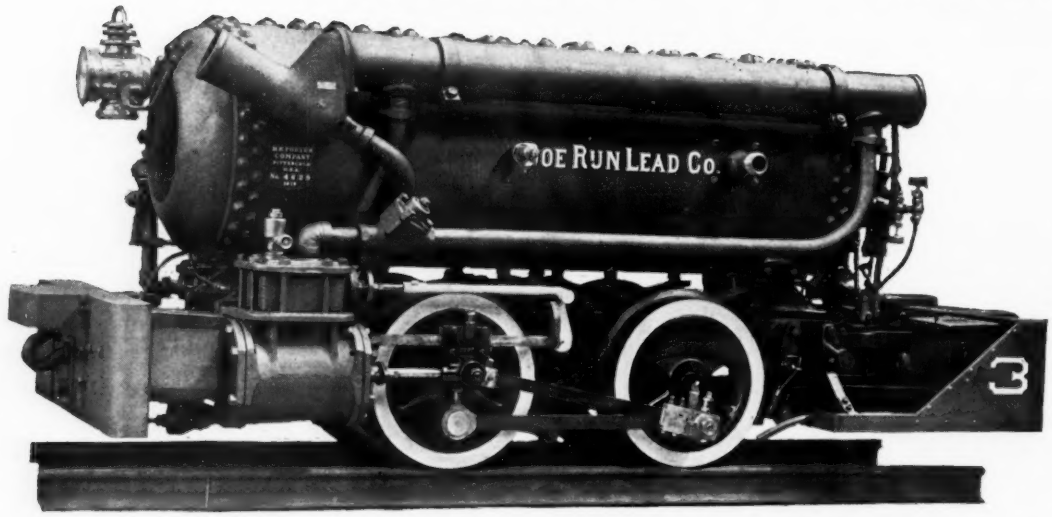
Fig. 10

Hyatt Roller Bearing

Floating axles often have to depend for their lubricant upon what is forced from the wheel. This is bad practice and has resulted in considerable trouble which could have been avoided if the axle bearings were positively lubricated.

Locomotives

The mule is being largely replaced in the mine by electric or air driven locomotives, though in some places the cars are still dragged to the gangways by mule. The electric locomotives are of low enclosed construction and may be driven by power from a trolley wire or from storage batteries. The trolley system is more apt to be used in main gangways and the battery in shorter leads. The air locomotives derive their power from storage tanks, where the air pressure may be as high as 1500 pounds per square inch. These are charged from the air compressors on the surface. Where the air is expanded in several stages, power is increased and extremely low temperatures avoided by using a heater between stages. This heater may be arranged like a condenser or feed water heater and the atmospheric air in the mine may be used as a heating medium. Electric locomotive axle bearings are lubricated according to the type of bearing, and the same recommendations apply as under Mine Cars. Gears, however, should use an adhesive lubricant of about 500″ viscosity at 210° F. on account of its ability to adhere to the gears and overcome vibration and gear wear, and at the same time be reasonably fluid at low temperatures. This same lubricant should be used on chain drives. Motor armatures may often get hot and burn



Courtesy of H. K. Porter Company

Fig. 11

Air-driven Mine Locomotive. Attention is called to the re-heater along the front side of the air tank.

out. This condition has often been blamed on the oil but it is now the consensus of opinion that poor bonding of rails is the cause of the armature trouble and not unsuitable oil.

Where locomotives are driven by compressed air, the cylinders should be lubricated by a medium bodied engine oil of 200″ to 300″ viscosity but with a low pour test, as these cylinders generally exhibit a heavy frost line, indicating a low temperature from the expansion of the air.

The cars, each carrying several tons of coal, are conveyed by the mine locomotive to the hoisting shaft where one or more are raised to the surface at a time. In drift mines the trains are run directly to the surface. The hoisting cables are wound up on drums which may be driven direct, or through gears, by means of reciprocating engines or electric motors. As these engines usually are a long distance from the boiler house and as the cylinders may become chilled on account of intermittent operation, they are therefore subjected to a large amount of steam condensation. This requires that a heavily compounded cylinder oil be used. The proper viscosity of the oil depends on steam temperature and position of lubricator in the feed pipe. External lubrication is usually accomplished by compression grease cups or hand filled gravity oil cups, using a medium grade of grease or oil. Where the hoisting drum is operated by means of a pinion drive from the hoisting engine it is necessary to use a lubricant that will withstand heavy pressures, heavy back lash that is encountered when engines are reversed, and at the same time possesses sufficient adhesive qualities to withstand the centrifugal force without throwing from the gears.

It has been found in practice that a heavy pure petroleum product of 2000″ Saybolt Viscosity at 210° F. will meet these conditions.

Cables

The wire rope used in connection with water, coal or rock hoist, is subjected to extremely severe conditions in regard to difference in temperature, the deteriorating action of sulphur or mine water, the lateral swaying of the ropes, twisting of the strands running over bull wheels and idler pulleys, and the high speeds at which these cables are operated. In order to successfully lubricate the internal strands of these ropes, and at the same time furnish a suitable film on the outside to prevent the destructive action of the mine water and elements, it is necessary that the lubricant shall adhere at all times and shall not harden or precipitate any objectional residue that is of a non-lubricating character. At the same time it must penetrate between the individual strands and furnish lubrication to the inside of the rope and thus prevent the water and deteriorating elements from coming in contact with the

strands. There are lubricants on the market of 1000″ viscosity at 210° F., made especially for this purpose, which will prove satisfactory. These products should be similar to the gear lubricant recommended above, with the exception of having a body or viscosity about one-half that of the gear lubricant. This product is best applied hot. This can be done by means of a split box containing the lubricant and through which the cable is allowed to run.

Pumps and Water Hoists

The water conditions in many mines are very bad. It is the usual practice to arrange sumps in the mine to which the water is drained by gravity. From these it is raised to the surface by pumps or water hoists. These pumps are of many makes, but they differ little in operating principle and may be classified in three distinct types, namely, the horizontal reciprocating steam pump, the vertical motor driven triplex pump, and the motor driven centrifugal pump. The horizontal reciprocating pumps are either steam or air driven. On the steam driven types the position of the lubricator in the feed pipe, the steam pressure and condition of steam should be taken into consideration the same as on all other steam equipment. However, it is found that steam cylinder oil from 130″ to 160″ viscosity, at 210° F., containing from 5% to 8% compound, will meet the average condition. These pumps are usually of the outside packed plunger type and require a lubricant to keep the packing properly sealed and prevent excessive wear on the plungers. For this purpose the same lubricant as recommended above in connection with the chain and gear drive on the electric locomotives should prove satisfactory, as this product will adhere to the plungers, work inside of the packing gland, lubricate the packing and prevent leakage. Should any of this material enter the pump chamber no harmful result will be experienced, as it will pass readily through the discharge valves along with the water.

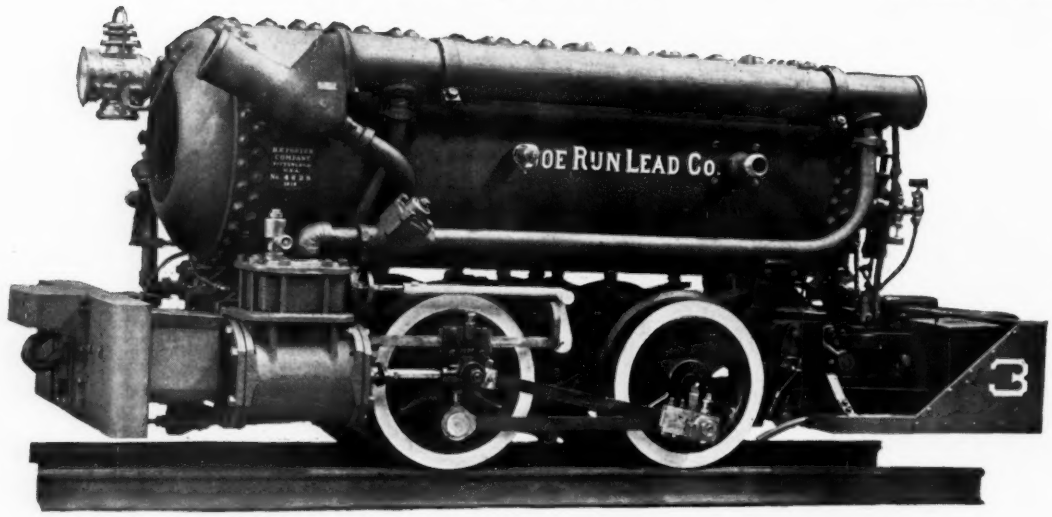
The vertical triplex pumps are lubricated either by means of compression grease cups, using a medium bodied cup grease, or gravity oil cups, using a medium bodied engine oil. On motor driven centrifugal pumps which are equipped with ring oiled bearings, a medium bodied engine oil is recommended on all bearings, including the thrust, where the former theory has required a heavy bodied oil, which is considered unsuitable for this condition. The lubrication of air driven pumps is similar to that of other air machinery discussed above.

Water hoists operate similarly to coal hoisting equipment, except that instead of bringing up coal cars the cables raise huge buckets containing 20 to 40 tons of water. The buckets are equipped with check valves which open at the bottom of the shaft but on being lifted remain closed until the bucket reaches the surface when the valve is again opened. In some modern mines these hoists are driven by electric motors which are so arranged as to reverse automatically. The lubrication of water hoist machinery is practically the same as coal hoisting.

Breakers

The cars laden with coal and brought up the shaft, are hauled to the breaker house where the coal is cleaned and sorted for the market. This is the practice in anthracite mining but in bituminous it is generally unnecessary to clean the product. The cars are hauled by steam or electric locomotives and the latter may be operated by trolley or storage battery. The electric locomotives are generally lubricated by a medium grade of grease or an engine oil of 200″ to 300″ viscosity. The lubrication of the steam locomotive is quite difficult from the fact that operators try to accelerate rapidly, thus causing the boiler to prime and carry considerable water into the cylinders. This is accentuated by the fact that the water is usually bad and boiler compound is used. A heavily compounded cylinder oil therefore is advisable and some lubricating engineers stipulate an unfiltered stock as a base for the oil.

These locomotives, which are small, depend on steam brakes and reversing mechanism, along with what are known as sprag pins, for stopping. The latter are nothing more than hard timber cut into lengths of from two to two and one-half feet, tapered at both ends, and approximately 5 inches diameter at the center. They are thrown into the spokes of the wheels of the rock cars, in such a manner as to lock them and cause the wheels to slide on the track. Boys operating sprag pins become



Courtesy of H. K. Porter Company

Fig. 11

Air-driven Mine Locomotive. Attention is called to the re-heater along the front side of the air tank.

out. This condition has often been blamed on the oil but it is now the consensus of opinion that poor bonding of rails is the cause of the armature trouble and not unsuitable oil.

Where locomotives are driven by compressed air, the cylinders should be lubricated by a medium bodied engine oil of 200″ to 300″ viscosity but with a low pour test, as these cylinders generally exhibit a heavy frost line, indicating a low temperature from the expansion of the air.

The cars, each carrying several tons of coal, are conveyed by the mine locomotive to the hoisting shaft where one or more are raised to the surface at a time. In drift mines the trains are run directly to the surface. The hoisting cables are wound up on drums which may be driven direct, or through gears, by means of reciprocating engines or electric motors. As these engines usually are a long distance from the boiler house and as the cylinders may become chilled on account of intermittent operation, they are therefore subjected to a large amount of steam condensation. This requires that a heavily compounded cylinder oil be used. The proper viscosity of the oil depends on steam temperature and position of lubricator in the feed pipe. External lubrication is usually accomplished by compression grease cups or hand filled gravity oil cups, using a medium grade of grease or oil. Where the hoisting drum is operated by means of a pinion drive from the hoisting engine it is necessary to use a lubricant that will withstand heavy pressures, heavy back lash that is encountered when engines are reversed, and at the same time possesses sufficient adhesive qualities to withstand the centrifugal force without throwing from the gears.

It has been found in practice that a heavy pure petroleum product of 2000″ Saybolt Viscosity at 210° F. will meet these conditions.

Cables

The wire rope used in connection with water, coal or rock hoist, is subjected to extremely severe conditions in regard to difference in temperature, the deteriorating action of sulphur or mine water, the lateral swaying of the ropes, twisting of the strands running over bull wheels and idler pulleys, and the high speeds at which these cables are operated. In order to successfully lubricate the internal strands of these ropes, and at the same time furnish a suitable film on the outside to prevent the destructive action of the mine water and elements, it is necessary that the lubricant shall adhere at all times and shall not harden or precipitate any objectional residue that is of a non-lubricating character. At the same time it must penetrate between the individual strands and furnish lubrication to the inside of the rope and thus prevent the water and deteriorating elements from coming in contact with the

strands. There are lubricants on the market of 1000″ viscosity at 210° F., made especially for this purpose, which will prove satisfactory. These products should be similar to the gear lubricant recommended above, with the exception of having a body or viscosity about one-half that of the gear lubricant. This product is best applied hot. This can be done by means of a split box containing the lubricant and through which the cable is allowed to run.

Pumps and Water Hoists

The water conditions in many mines are very bad. It is the usual practice to arrange sumps in the mine to which the water is drained by gravity. From these it is raised to the surface by pumps or water hoists. These pumps are of many makes, but they differ little in operating principle and may be classified in three distinct types, namely, the horizontal reciprocating steam pump, the vertical motor driven triplex pump, and the motor driven centrifugal pump. The horizontal reciprocating pumps are either steam or air driven. On the steam driven types the position of the lubricator in the feed pipe, the steam pressure and condition of steam should be taken into consideration the same as on all other steam equipment. However, it is found that steam cylinder oil from 130″ to 160″ viscosity, at 210° F., containing from 5% to 8% compound, will meet the average condition. These pumps are usually of the outside packed plunger type and require a lubricant to keep the packing properly sealed and prevent excessive wear on the plungers. For this purpose the same lubricant as recommended above in connection with the chain and gear drive on the electric locomotives should prove satisfactory, as this product will adhere to the plungers, work inside of the packing gland, lubricate the packing and prevent leakage. Should any of this material enter the pump chamber no harmful result will be experienced, as it will pass readily through the discharge valves along with the water.

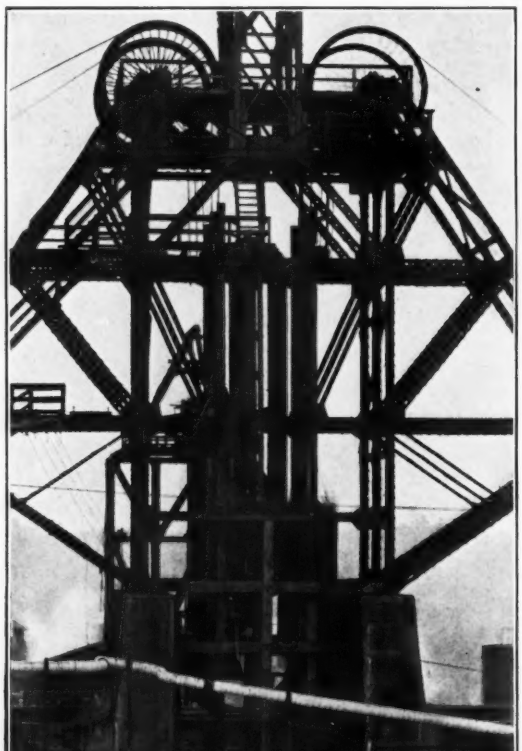
The vertical triplex pumps are lubricated either by means of compression grease cups, using a medium bodied cup grease, or gravity oil cups, using a medium bodied engine oil. On motor driven centrifugal pumps which are equipped with ring oiled bearings, a medium bodied engine oil is recommended on all bearings, including the thrust, where the former theory has required a heavy bodied oil, which is considered unsuitable for this condition. The lubrication of air driven pumps is similar to that of other air machinery discussed above.

Water hoists operate similarly to coal hoisting equipment, except that instead of bringing up coal cars the cables raise huge buckets containing 20 to 40 tons of water. The buckets are equipped with check valves which open at the bottom of the shaft but on being lifted remain closed until the bucket reaches the surface when the valve is again opened. In some modern mines these hoists are driven by electric motors which are so arranged as to reverse automatically. The lubrication of water hoist machinery is practically the same as coal hoisting.

Breakers

The cars laden with coal and brought up the shaft, are hauled to the breaker house where the coal is cleaned and sorted for the market. This is the practice in anthracite mining but in bituminous it is generally unnecessary to clean the product. The cars are hauled by steam or electric locomotives and the latter may be operated by trolley or storage battery. The electric locomotives are generally lubricated by a medium grade of grease or an engine oil of 200″ to 300″ viscosity. The lubrication of the steam locomotive is quite difficult from the fact that operators try to accelerate rapidly, thus causing the boiler to prime and carry considerable water into the cylinders. This is accentuated by the fact that the water is usually bad and boiler compound is used. A heavily compounded cylinder oil therefore is advisable and some lubricating engineers stipulate an unfiltered stock as a base for the oil.

These locomotives, which are small, depend on steam brakes and reversing mechanism, along with what are known as sprag pins, for stopping. The latter are nothing more than hard timber cut into lengths of from two to two and one-half feet, tapered at both ends, and approximately 5 inches diameter at the center. They are thrown into the spokes of the wheels of the rock cars, in such a manner as to lock them and cause the wheels to slide on the track. Boys operating sprag pins become



Courtesy of Lehigh Coal & Navigation Co.

Fig. 12

Water Hoist

so expert that they can stop a train within a few feet of the desired spot.

The cars full of coal are turned over bodily so as to dump their contents onto a conveyor belt, or they may be carried to the top of the breaker or tipple before dumping. The coal is then crushed and made ready for sorting and cleaning. The sorting is done by passing the coal through large rotating or reciprocating screens. It is then passed to the picking or cleaning machines. Picking formerly was done by boys who stood along a chute and picked out the slate and rock as the coal slid by. Now there are several types of machines designed to accomplish this purpose. There are in general three methods used: (1) The unpicked coal is run down a spiral chute where, due to the greater density of the rock and slate over that

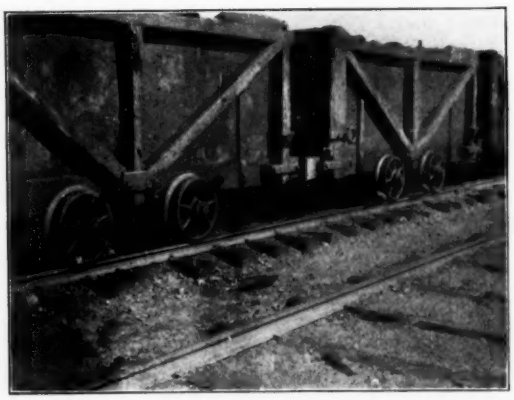
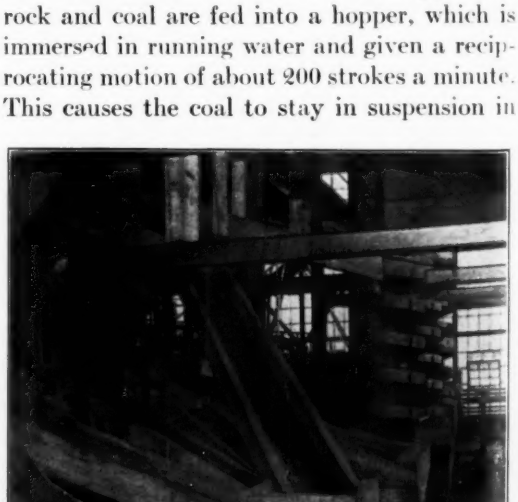


Fig. 13

Mine Cars Being Stopped by the Use of Sprag Pins

of the coal the former are thrown to the outside of the chute by centrifugal force and can be separated from the coal. (2) The coal and rock are passed over rollers running about 140-150 r.p.m. On account of the low density of the coal, the rotating roll easily imparts some of its momentum to the coal and throws it away from the rock and down a special chute while the rock drops down close to the roller. These rollers are generally arranged in a series. (3) The third method is the coal jig. The principle of the jig is again a matter of relative density between the coal and the rock. In this apparatus rock and coal are fed into a hopper, which is immersed in running water and given a reciprocating motion of about 200 strokes a minute. This causes the coal to stay in suspension in



Underwood & Underwood

Fig. 14

Inside of a Breaker House. Notice spiral coal and rock separators.

the water and wash over a weir with the water. The rock and slate drop through the hopper and are conveyed away by bucket elevators or belt conveyors. The coal being wet, it is necessary to lubricate and protect the bucket elevator chains and sprockets with the same heavy lubricant used to protect the wire ropes, which the water will not wash off.

The coal breaker, whether driven by engine or motor, is usually lubricated by a medium grade cup grease, for by keeping the grease under pressure, coal and rock dust is kept out of the bearings. In coal breakers operated on the wet system, where coal is run through a breaker using water in all processes, the gears can be efficiently lubricated with the same gear compound mentioned in connection with the gears and pinions on hoisting engines. With coal breakers operating on the dry principle it is a difficult matter to lubricate the gears, owing to the large amount of dust encountered, which mixes with the gear compound, causing it to lose its adhesiveness, thus necessitating frequent applications in order to properly lubricate the gears. Many plants use cheap black or waste oil for this purpose, as it can be applied frequently at a very small cost.

Dredging

In the early days of anthracite mining, the demand was only for the larger sizes, known as egg, stove and nut coal. Due to the small amount of revenue that could be obtained from the smaller sizes, they were permitted to pass through the screens in washeries and follow the water courses into creeks and rivers. Today, owing to the market price of what is known as steam sizes, covering rice, buckwheat and pea coal, the dredging of these streams and rivers has proved a profitable venture for many small coal companies. The equipment usually consists of small donkey boiler, small steam engine agitator which stirs up the river or creek bottom, and centrifugal pumps that pump up the agitated bottom through screens, reclaiming the coal that had been previously dumped into the streams as worthless. The lubrication of this equipment is comparatively simple, being accomplished by a steam cylinder oil from 100″ to 130″ viscosity at 210° F. with from 3% to 8% compound, a medium bodied engine oil for external lubrication of engines and pumps, and a 1000″ viscosity lubricant at 210° F. for lubrication of chains driving agitators and screens.

Stripping

Where the coal lies within 200 feet of the surface it often can be successfully mined by stripping. This is accomplished by means of modern steam and electric shovels which remove the upper surface in order to reach the coal. Steam cylinder lubrication on the steam shovels is accomplished by means of a cylinder oil with a viscosity of 130″ to 160″ at 210° F., depending on the steam pressure, and with 5% to 8% compound. External lubrication is accomplished by means of a blended engine oil with a viscosity of about 750″ at 100° F. fed either through waste packed bearings or gravity oil cups. Compression grease cups are used on many parts that are not convenient for oiling, and a pure petroleum product of 1000″ viscosity at 210° F. is the best product for gear lubrication. This coal after mining is run through breakers for sizing and picking as previously described.

Conclusion

We have indicated above in general the types of lubricants which appear to us most suitable for the various classes of machinery found in or around a mine. But even the best of lubricants cannot be expected to give maximum service unless the machinery is taken care of and proper and systematic attention is paid to the application of the lubricant. An ample and well lighted place for oiling should be provided; a system of marking should be used, indicating the date of oiling a car or motor; a good oiling device should be used that regulates the quantity of lubricant applied; apparatus should be kept in proper condition as to prevent waste; and of most importance the operator in charge should be educated along lubricating lines so that he understands what he is doing and why he is doing it. Each machine is a part of a system and the temporary loss or laying up of any machine may cause the shut down of others, and an increase of expense with loss of production. There is no factor more apt to cause a breakdown than the lack of proper lubrication.

Notes From Engineers' Handbooks

Air Compressor Lubricant

A large Car and Foundry Company operating many air compressors were strongly convinced that the proper oil for the air as well as the steam cylinder end of the compressor was steam cylinder oil. They held this view in spite of recommendations of engineers to the contrary. A short time ago this Company had a minor air line explosion which gave them grave concern and caused them to make an investigation in order to ascertain the reason. As there was a possibility of the lubricating oil being involved a Lubricating Engineer was consulted.

In this investigation it was found that a large two stage compressor was used to raise the air to 130 pounds pressure. Upon opening up this apparatus it was found that the discharge chambers, the air lines and receivers, as well as the inter-coolers, were heavily coated with a hard flinty carbon. This had apparently resulted from the use of the cylinder oil. It was believed that there was a possibility that the explosion was due to this carbon, and so after cleaning out the apparatus as well as possible a comparatively light oil with a viscosity of about 180″ was applied to the system. After running a short time the carbon not already cleaned out commenced to loosen throughout the system to such an extent as to plug the control valves and air hammers. The oil finally so cleaned out the lines that all carbon was removed and there was no further difficulty, the cylinders being found clean when investigated. It was also found that there was sufficient oil carried through the system to lubricate the air tools, which previously had been lubricated with a squirt can. Due to the use of the light oil not only was the carbon eliminated but the consumption necessary for efficient operation was cut down to a marked degree.

As this oil was carried through the lines, a question arose as to the effect of the oil on the rubber air hose. A protracted investigation proved, however, that while there might be a slight effect on the hose by the oil, practically the hose became worn out from other causes long before the solvent action of the mineral oil had any appreciable effect on the rubber.

Watch Your Safety Valve

Recently an engineer was required to investigate the burning out of soft plugs in the air receivers on an air lift system. The Plant Engineer in charge of this equipment was inclined to believe that the burning out of these plugs was caused by the oil being carried through the system into the receivers and there carbonizing and burning, thus causing the soft plugs to soften and blow. As the investigating engineer could not see how this could happen he made a thorough study of the whole system in order to ascertain if the trouble was not due to some other cause.

It was found that very small quantities of oil were being fed to the compressors and that when they were opened they were in excellent condition as to carbonization and quantity of oil on the walls. The valve was removed from one of the machines situated closest to the receiver, and it was found to be clean and entirely free of carbon. No carbon could be found anywhere in the system and it did not seem reasonable to conclude that the carbon was lodging in the air receiver only.

The Plant Engineer was diplomatically questioned as to his method of operation and it was found that it was his custom prior to shutting down his machine to close the valve from the receivers to the lift system. As the capacity of the receivers was not large a pressure could be built up very rapidly, sufficient to blow the soft plugs. In order to prevent this a safety valve was placed in the line. An investigation of this valve showed that it could hardly be moved by hand. It had not received proper care and was set at a pressure too high for the soft plugs to withstand. Do not blame the oil until you are sure that your mechanical conditions are not at fault.

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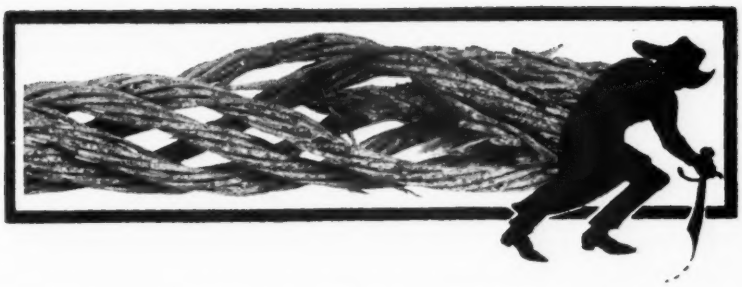

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